Original Research Article

Interaction of Wealth, Residence and Region on Multiple Anthropometric Failure among Under-Five Children in Nigeria

ABSTRACT

Aim: This study examined the prevalence of multiple anthropometric failures among Nigerian children under five years of age using the Composite Index of Anthropometric Failure (CIAF) and examined the interactions between wealth, residence and regional strata.

Study design: A retrospective cross-sectional study.

Methodology: This study used dataset from the kids recode file of 2018 Nigeria Demographic and Health Survey (NDHS) with a weighted sample of 11323 under-five children. Data from the 2018 NDHS were analysed to compute CIAF indices and assess the prevalence of anthropometric failures across 12 intersecting subgroups, defined by three domains of inequality: wealth (rich/middle/poor), place of residence (urban/rural), and region (north/south). Cross tabulation and logistic regression were carried out to assess the odds of the CIAF among interacting groups. A choropleth map was created using ARCGIS software to describe the regional clustering of CIAF in Nigeria. All analyses were carried out using IBM Statistical Package for Social Sciences (SPSS) (version 20) and significance placed at 0.05.

Results: Overall, 40.8% of children showed composite anthropometric failure, with 20.7% experiencing at least one failure and 3.1% suffering from all three forms of undernutrition concurrently. Cross-matching these domains revealed the highest CIAF prevalence (60.3%) among children from rural-poor households in northern Nigeria, while the lowest prevalence (31.3%) was recorded among urban-rich households. The findings indicate significantly lower odds of CIAF among children from wealthier households in southern Nigeria, highlighting the importance of socio-economic and regional disparities.

Conclusion: This study underscores the need for targeted nutritional interventions for the most vulnerable subgroups, emphasizing the limitations of single-dimensional inequality analyses in policy formulation and program implementation. Instead, it advocates for detailed intra-district and state-level analyses of socio-economic disparities, particularly among marginalized groups, to design equitable and context-specific strategies to address child nutritional disparities effectively.

Keywords: CIAF, Under-five, Nigeria,

1. INTRODUCTION

Child malnutrition is a critical public health issue that significantly hinders children's development. In 2020, global estimates indicated that approximately 149 million children under five were stunted, 59 million were wasting, and 85 million were moderately or severely underweight (WHO, 2021).

Nigeria, the most populous nation in Africa, is a high burden country for chronic undernutrition, accounting for 8% of the world's stunted children and more than half of stunted children in West Africa. In 2020, Nigeria had over 11.9 million stunted children under the age of five, ranking the country as the second-highest in West Africa for stunting prevalence (UNICEF, 2021).

Child undernutrition in Nigeria is unequally distributed, with marked disparities along a north-south divide as well as across social groups, economic status, religious affiliations, geographic locations, and gender (Gayan et al., 2019). Socioeconomic disparities in stunting and wasting vary by geopolitical zone, with key determinants being wealth, maternal education, and religious background differences. Factors such as under-five dependency, availability of improved toilet facilities, and geographic region notably contribute to stunting inequalities and access to improved water facilities is a major determinant in the unequal distribution of wasting (Nwosu & Ataguba, 2020). A geospatial analysis highlights that patterns of stunting, wasting, and underweight exhibit distinct regional distributions, pointing to the need for targeted regional interventions (Amir-ud-Din et al., 2022). Additionally, neighbourhood socioeconomic status, wealth index, sanitation, and water sources significantly impact rural-urban disparities in child undernutrition, with birth weight, maternal age, and maternal education playing further roles (Fagbamigbe et al., 2020b).

Disparities are also evident when comparing household wealth and maternal education levels. Stunting, underweight, wasting, and anemia prevalence are significantly lower among children from wealthier households, whereas higher rates of these conditions are observed in children from lower-income families. Furthermore, under-five survival rates are considerably higher among children whose mothers have attained higher educational levels compared to those with less-educated mothers. Conversely, children of mothers with lower educational attainment exhibit higher rates of stunting, underweight, wasting, overweight, and anaemia (Ekholuenetale et al., 2020). Significant differences are also observed between urban and rural children, with rural children showing higher rates of stunting, underweight, and wasting across household wealth and maternal education categories. These findings underscore the importance of addressing socioeconomic and educational inequalities to reduce regional and social disparities in child undernutrition.

The Composite Index of Anthropometric Failure (CIAF) is a metric designed to identify children experiencing single, multiple, or overall anthropometric failures by integrating three key indices: weight-for-age, height/length-for-age, and weight-for-height/length. This comprehensive measure allows for a nuanced assessment of the nutritional status of children under five. Using the Svedberg model, the CIAF classifies malnourished children into six distinct categories: (A) no anthropometric failure; (B) wasting only; (C) wasting and underweight; (D) wasting, underweight, and stunting; (E) underweight and stunting; and (F) stunting only. Nandy & Svedberg (2012) further expanded this model by adding a seventh category, (Y), for children who are underweight only (Nandy & Svedberg, 2012) (Table 1).

Table 1: The seven (7) groups of the Composite Index of Anthropometric Failure (CIAF)

Group	Interpretation
A No failure	Adequate height and weight (>-2 Z-score)
B Wasting only	Low Weight for Height Z-score only
C Wasting & underweight	Low Weight for Height Z-score, low weight for Age Z-score
D Wasting, stunting & underweight	Low Weight for Height Z-score, Weight for Age Z-score and Height for Age Z-score
E Stunting & underweight	Low Height for Age Z-score, low Weight for Age Z-score
F Stunting only	Low Height for Age Z-score only
Y Underweight only	Low Weight for Age Z-score only

The Composite Index of Anthropometric Failure (CIAF) is extensively used to assess the prevalence of single, multiple, and overall anthropometric deficiencies in young children. Research has shown that children experiencing multiple anthropometric failures are at a markedly increased risk of morbidity and mortality, highlighting the CIAF's critical role in identifying at-risk populations (McDonald et al., 2013). Regional analyses of infant and child mortality further reveal that areas with a higher incidence of multiple anthropometric failures tend to exhibit elevated mortality rates. Distinct from prior studies that rely on traditional nutritional indices, recent research has employed the CIAF to more precisely capture severe undernutrition among Indian

children and examine its relationship with infant and child mortality at a district level (Khan & Das, 2020).

Additionally, a potential additive association between multiple anthropometric failures and early childhood developmental outcomes has been identified (Jeong et al., 2019). These studies underscore the value of using varied approaches, such as the CIAF, to fully understand anthropometric failure (AF) and inform policies and programs targeting AF prevention. Utilizing the CIAF may enhance treatment efforts, supporting accelerated progress towards achieving Sustainable Development Goals (Gausman et al., 2022). From a policy and programmatic standpoint, the CIAF serves as an effective tool for pinpointing nutritionally deprived groups, particularly given the elevated mortality risks among those with overlapping nutritional deficiencies. By revealing the convergence of multiple anthropometric failures, the CIAF allows for in-depth analysis across intersecting factors such as wealth, residence, and region, aiding in identifying the most vulnerable social sub-groups suffering from severe undernutrition. Moreover, in Nigeria, where regions differ significantly in dietary practices, social norms, and economic disparities, identifying regions with the highest undernutrition burden through CIAF could lead to more equitable policy-making and intervention strategies. This approach, combined with intersectional analysis, offers a robust framework for identifying high-priority districts and regions, thereby guiding targeted, context-specific nutritional interventions and enabling precise financial allocation to those areas in greatest need.

2. METHODOLOGY

This study used datasets from the kid's recode file of the 2018 Nigeria Demographic and Health Survey (NDHS). This NDHS dataset is the sixth in the series of nationally representative surveys that collect information on basic demographic and health indicators in Nigeria. Comprehensive survey methodology, including sample design and data collection procedure, was published in the NDHS Report for the 2018 survey year (NDHS 2018). The dataset was downloaded after

obtaining permission from ICF Inc. USA to use it for this study. The kids recode file within the dataset provides comprehensive information on pregnancy, postnatal care, immunization, health, and nutrition for children under five born to women aged 15–49 years across all Nigerian states and the Federal Capital Territory. This dataset provided information on child health indicators, including immunization coverage, vitamin A supplementation, recent episodes of diarrhoea, fever, and cough among young children, as well as treatment for childhood illnesses, nutritional status, and malaria prevention and treatment practices.

The key variable in the analytical sample was values for the weight, height and age of children (0-59 months) from the secondary data. There were weighted samples of 11323 children under five years of age with reported numerical values for weight, height and age. Multiple anthropometric failure indices were created, namely: Wasting only; Wasting & Underweight; Stunting only; Stunting & Underweight; Underweight only; Wasting, Stunting and Underweight (Composite Indicator for Anthropometric Failure-CIAF) including No failure (*Figure 1- the Venn Diagram figure*). A total of 12 interacting subgroups were considered based on interactions across three main domains of inequality i.e., Wealth (Rich, Middle and Poor), Place of Residence (Urban and Rural) and Region (North and South). (Table 2)

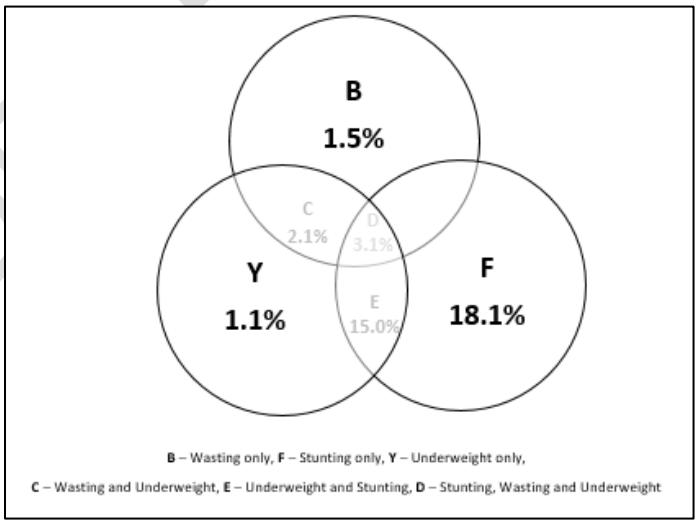


Figure 1: Overlapping nature of anthropometric failures

Table 2: Interacting Subgroups based on interactions across three main domains of inequality

	Domains of Inequality		Interacting Subgroups
Region	**Place of Residence**	**Wealth Index**	
North	Urban	Rich	North Urban Rich
	Rural	Middle	North Urban Middle
		Poor	North Urban Poor
			North Rural Rich
			North Rural Middle
			North Rural Poor
South	Urban	Rich	South Urban Rich
	Rural	Middle	South Urban Middle
		Poor	South Urban Poor
			South Rural Rich
			South Rural Middle
			South Rural Poor

2.1. Outcome and exposure variables

The outcome variable in this study is the anthropometric failure, measured using three main indicators: stunting, wasting, and underweight. The exposure (independent) variables, including region, place of residence and wealth index, were grouped into 12 subgroups, as shown in (Table 1). The community variable, region, was based on geopolitical delineations in the country and re-categorized into North region (comprising Northcentral, Northeast and Northwest) and South region (comprising Southeast, Southsouth and Southwest). Individual-level variables- Place of residence was classified into rural and urban, and wealth-index was regrouped into poor, middle and rich. Child Anthropometry was classified into stunted (low height-for-age, ≤-2SD); wasted (low weight-for-height, ≤-2SD) and underweight (low weight-for-age ≤-2SD).

2.2. Statistical Analysis

The statistical analysis was at bivariate level. Cross tabulation was carried out between social groups and CIAF to show the pattern of CIAF in region, residence and household wealth. The logistic regression model, with no anthropometric failure as a reference group, was used to predict the odds of composite anthropometric failure across the interacting subgroups or domains of inequality, showing the risk among the most vulnerable social and geographical subgroups.

3. RESULTS AND DISCUSSION

3.1. Types of anthropometric failures among children

The result showed a Composite Index of Anthropometric Failure (CIAF) prevalence of 40.8% among children under five, surpassing the 2018 NDHS reported prevalence rates of stunting (36.8%), underweight (8.9%), and wasting (5.6%). Among CIAF classifications in Figure 1, 20.7% of children experience a single form of anthropometric failure (groups B, F, and Y), while 17.1% suffer from two simultaneous failures (groups C and E), and 3.1% exhibit all three types of anthropometric failure (Table 1). Simultaneous failures of stunting and underweight combined (15.0%; group E) represented the most common form of anthropometric failures. Regional and socioeconomic disparities were evident, as children from the Northern Poor, in both rural and urban areas, appeared particularly disadvantaged compared to those from the Southern Poor. Notably, Northern Rural Poor (NRP) children have the highest rate of three simultaneous anthropometric failures (60.3%). Analysis by wealth index and the intersectional analysis showed economic position as a significant factor affecting the nutritional status of children as measured by the CIAF, with notable disparities between children from poor, middle, and rich economic backgrounds. Regardless of residence or region, children from wealthier households consistently demonstrated lower CIAF prevalence. The highest CIAF prevalence was observed among the North Rural Poor (NRP), and the lowest among the South Urban Rich (SUR). Stunting alone was more prevalent among the North Urban Poor (NUP), while stunting and underweight combined were common among the NRP. Wasting alone, along with wasting and underweight combined, was highest among the North Urban Middle (NUM), and the highest prevalence of all three

failures was again noted among the NRP. Additionally, underweight alone was more common among children in the South Rural Middle (SRM) groups.

3.2. Intersectional inequality

Bivariate analysis of the CIAF and all three anthropometric failures revealed significant variations by economic position and residence (Table 3). However, examining these differences across intersectional sub-groups of residence, region, and wealth showed that the significant disparities were unevenly distributed. In the northern areas, the economic differences in all three anthropometric failures were notable among rural middle-income, and both rural and urban rich groups, yet these differences were not evident among urban middle-income and poor groups. The economic position-based disparities among Southern children remained significant across all sub-groups, regardless of residence. For CIAF, economic position disparities were consistently significant across all groups by residence and region, except for the North Urban Poor (NUP) group (see Table 3).

Table 3: Distribution of CIAF by interactions of Region, Residence and Household wealth

Subgroups	N	%	Wasting only	Wasting and Underweight	Wasting, Stunting and Underweight	Stunting and Underweight	Stunting only	Underweight only	CIAF
North Rural Poor	3515	31.0	1.8	2.1	5.8	25.7	23.8	1.1	60.3
North Urban Poor	294	2.6	2.0	2.4	4.4	18.4	28.9	0.3	56.5
North Urban Middle	450	4.0	2.4	2.7	3.6	17.6	20.7	1.6	48.4
North Rural Middle	968	8.5	1.9	2.2	3.2	15.8	23.6	0.8	47.4
North Rural Rich	459	4.1	0.7	2.8	2.2	10.5	16.1	1.3	33.6

North Urban Rich	1041	9.2	0.9	1.7	1.5	10.0	15.8	1.4	31.3

Subgroups				**CIAF**			**ALL THREE**		
South Rural Middle	606	5.4	1.3	2.1	1.2	10.7	16.3	1.7	33.3
South Rural Poor	417	3.7	0.2	2.4	2.2	9.1	17.7	1.2	32.9
South Urban Middle	480	4.2	1.0	2.3	1.5	11.5	15.2	1.0	32.5
South Urban Poor	261	2.3	0.8	2.3	1.1	10.3	16.1	1.1	31.8
South Rural Rich	925	8.2	1.2	2.3	0.8	6.2	10.8	0.9	22.1
South Urban Rich	1907	16.8	1.5	1.6	1.3	5.8	9.3	1.1	20.6
Total	**11323**	**100.0**	**1.5**	**2.1**	**3.1**	**15.0**	**18.1**	**1.1**	**40.8**

Table 4 presents the associations between place of residence and malnutrition indices, illustrating a general trend of decreasing odds of a child experiencing CIAF or all three forms of malnutrition (stunting, wasting, and underweight) from the North Urban Poor to the South Urban Rich. A notable deviation from this pattern is the slight advantage observed among the Northern Urban Rich compared to the Southern Urban Poor, a difference more pronounced for CIAF than for the co-occurrence of all three malnutrition indices.

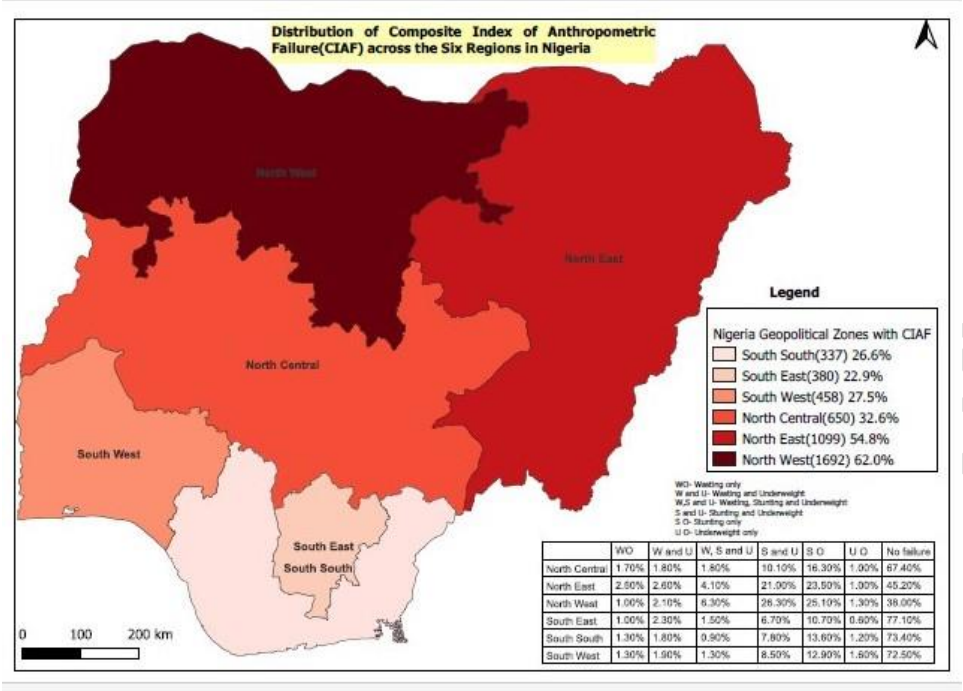
Table 4: Logistic regression of associations between residence and indices of anthropometric failures among under five Children

	OR	LCI	UCI	OR	LCI	UCI
North Rural Poor (ref.)	1.00			1.000		
North Urban Poor	0.855	0.673	1.088	0.755	0.425	1.340
North Urban Middle	0.620*	0.509	0.755	0.601	0.358	1.010
North Rural Middle	0.595*	0.515	0.686	0.540*	0.367	0.793
North Rural Rich	0.333*	0.271	0.409	0.363*	0.191	0.691
North Urban Rich	0.301*	0.260	0.348	0.255*	0.152	0.426
South Rural Middle	0.330*	0.275	0.396	0.191*	0.089	0.407
South Rural Poor	0.323*	0.260	0.400	0.360*	0.183	0.707
South Urban Middle	0.318*	0.259	0.389	0.241*	0.113	0.516
South Urban Poor	0.308*	0.235	0.403	0.190*	0.060	0.597
South Rural Rich	0.187*	0.158	0.221	0.124*	0.058	0.265
South Urban Rich	0.171*	0.150	0.195	0.217*	0.143	0.330

**significant at P=.05*

3.3. Region-based undernutrition hotspots in Nigeria

The prevalence of co-occurring at least two simultaneous anthropometric failures (e.g., stunting and underweight at 80.4%, wasting and underweight at 12.5% and all three failures - stunting, wasting, and underweight at 15.9%) highlights critical regional disparities in malnutrition across Nigeria (Figure 2). Regions were classified as critical (North West), very serious (North East), and seriously affected (North Central) based on these prevalence rates. In the North West, designated as the critical region, 61.1% of children experienced at least two simultaneous anthropometric failures. The North East, identified as a very serious region, reported 27.7% of children with at least two anthropometric failures, nearing the threshold for classification as a critical region, with rates of 11.5% for wasting and underweight, 21.2% for all three failures, and 32% for stunting and underweight. The spatial distribution of these critical, very serious, and serious prevalence rates demonstrates significant geographical clustering of undernutrition hotspots across four regions: North West, North East, North Central, and South West (Figure 2).



	WO	W and U	W, S and U	S and U	S O	U O	No failure
North Central	1.70%	1.80%	1.80%	10.10%	16.30%	1.00%	67.40%
North East	2.50%	2.60%	4.10%	21.00%	23.50%	1.00%	45.20%
North West	1.00%	2.10%	6.30%	26.30%	25.10%	1.30%	38.00%
South East	1.00%	2.30%	1.50%	6.70%	10.70%	0.60%	77.10%
South South	1.30%	1.80%	0.90%	7.80%	13.60%	1.20%	73.40%
South West	1.30%	1.90%	1.30%	8.50%	12.90%	1.60%	72.50%

Figure 2: Distribution of Composite Index of Anthropometric Failure (CIAF) across the Six Regions in Nigeria

DISCUSSION

The study confirms the persistently high prevalence of undernutrition in this population, as documented in existing literature (Samuel, 2014; Nwosu & Orji, 2018; Khan & Das, 2020; Adesuyi et al., 2021; Kochupurackal et al., 2021; Channa Basappa et al., 2021; Permatasari, 2022). Undernutrition remains a leading underlying cause of disease and mortality among under-five children, particularly in low- and middle-income countries (WHO, 2021), and contributes to disability, impaired cognitive and physical development, and increased susceptibility to infections (Kalu & Etim, 2018; Hall et al., 2020; Govender et al., 2021). While previous research identified regional hotspots of undernutrition based on individual measures such as stunting, wasting, and underweight (Nwosu & Orji, 2018; Adesuyi et al., 2021), this study utilises CIAF to provide a comprehensive view. The integration of CIAF with intersectional analysis provides a nuanced understanding of child nutritional inequality and captures the biological gradients of undernutrition severity. The intersectional analysis reveals the overlapping social dimensions contributing to nutritional disparities. The findings highlight the Northern region, particularly the North West, as having the highest concentration of multiple anthropometric failures, aligning with earlier studies (Alarape et al.,

2022; Amusa et al., 2023). Although hotspot identification aids in setting national priorities, undernutrition remains prevalent in various regions, including urban settings such as Oyo State (Bamisaye & Adepoju, 2018) and other urban areas with notably low nutritional status (Ozor et al., 2014; Jude et al., 2019). Sub-groups disadvantaged across multiple dimensions—such as those from marginalized communities in rural areas—warrant prioritised intervention efforts.

Common risk factors, including household poverty, maternal education deficits, and inadequate access to safe drinking water and sanitation facilities, are widespread across regions (Agu et al., 2019; Ahmed et al., 2023; Lawal et al., 2023). In the North, cultural factors such as early marriage, large household sizes, and Fulani ethnic identification further exacerbate child undernutrition (Abiodun et al., 2019; Akpan & Isihak, 2020; Mukaila et al., 2022). Urban poverty is unevenly distributed across states, with poorer states hosting a higher concentration of urban poor, potentially intensifying undernutrition hotspots in these regions (Jaiyeola & Bayat, 2020; Bosah & Nwanolue, 2023). Regional disparities in urban migration and rural-urban inequalities further complicate the patterns of child undernutrition across Nigeria. This approach underscores the need for targeted, multi-faceted strategies to address the complex interplay of biological and social determinants of child undernutrition.

4. CONCLUSION

This study highlights anthropometric failures' social and eco-geographical clustering, emphasizing the urgent need for targeted nutritional interventions for Northern Rural Poor (NRP) and Northern Urban Poor (NUP) children from low-income households. The clustering of districts into critical, very serious, and serious undernutrition hotspots underscores the importance of prioritizing these areas for interventions and adopting decentralised planning approaches that account for sociodemographic, economic, and eco-geographical factors. The findings caution against relying solely on single-dimensional analyses of inequality in policy formulation and program implementation. Instead, they advocate for investigating intra-district and state-level socio-economic disparities, particularly among marginalised groups, to effectively design tailored, equitable interventions that address child nutritional disparities.

ETHICAL APPROVAL

Ethical clearance to conduct Nigeria Demographic and Health Surveys was obtained from National Health Research Ethics Committee of Nigeria (NHREC) and the ICF Institutional Review Board., United States. NDHS data are public access data and permission was granted to download the dataset for this study by Demographic and Health Survey Program of ICF Macro. The authors also assert that all procedures contributing to this work comply with the ethical standards of the relevant national and institutional committees on human experimentation and with the Helsinki Declaration of 1975, as revised in 2008.

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